ADMINISTRATIVE INFORMATION

1. **Project Name:** Low-Temperature Surface Carburizing of Stainless Steels (CPS#16948)

2. **Lead Organization:**
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5. **Date Project Initiated:** 1 January 2004

6. **Expected Completion Date:** 31 December 2006

PROJECT RATIONALE AND STRATEGY

7. **Project Objective:**
This research program will apply a commercial patented technology, currently used for conformal surface hardening AISI 316 components, to other austenitic stainless steel components. Austenitic stainless steels that have been treated by this technology, called low-temperature colossal super-saturation (LTCSS), show increased surface hardness, improved wear resistance, improved erosion resistance, and improved corrosion resistance. The research will enable substantial reduction of the service-induced wear of

austenitic stainless steel parts in a variety of applications, including, for example, bearing surfaces and wear surfaces.

8. **Technical Barrier(s) Being Addressed:**

Austenitic stainless steels are the primary materials of choice for applications when one needs corrosion resistance in aqueous solutions at ambient temperatures. While austenitic stainless steels are excellent for their corrosion resistance, they possess low hardness values and cannot be heat-treated to increase their hardness like the ferritic steels. Thus, when used for applications such as pumps for liquids and slurries in chemical, petrochemical, pulp and paper, steel, and other industries, they undergo wear of the pump impellers and the pump casings. The wear causes the pumps to operate with decreasing efficiency.

9. **Project Pathway:**

Swagelok will process a group of commercially available austenitic stainless steels, and perform initial characterization, including metallography, microhardness depth profiles, carbon depth profiles, and some screening corrosion testing. CWRU will characterize the carburized specimens using materials characterization techniques such as TEM, SEM, and XRD, and will perform mechanical tests as required. CWRU will also perform thermodynamic modeling to evaluate the effects of different alloying elements on the results of the LTCSS process. ORNL will be responsible for corrosion, fatigue, and tribological testing (erosion, wear, abrasion) of a subset of the treated alloys. ORNL will also be responsible for the production of test heats of an austenitic alloy designed to optimize the results of the LTCSS process (depth of treatment and hardness of case). EIO will provide marketing support and components for treatment. Spirax Sarco will provide components for treatment and will test the components to evaluate the improvement in energy efficiency.

10. **Critical Technical Metrics:**

Extend the LTCSS technology to other stainless steels: Thirty candidate alloys have been identified for evaluation. These alloys are readily available, commercially important in a wide range of industries, and also represent a range of compositions. Alloys will be considered successfully treated when the following parameters are achieved:

- At least double the hardness of untreated material: verified by microhardness profiles
- Uniform treatment (complete activation): verified by metallographic evaluation
- No carbide precipitation: verified by TEM and XRD analyses
- Performance improved over untreated material: verified by testing

Create pedigreed data on performance characteristics of treated alloys: When possible, standard ASTM test methods will be used, and metric rather than subjective data will be generated.

Develop understanding of effects of alloying elements on LTCSS results: By optimizing the composition of the stainless steel, much higher levels of carbon super-saturation can be reached, and these higher carbon concentrations will result in an even more impressive increase of the surface hardness and the wear- and corrosion-resistance. This concept will be examined using thermodynamic modeling.

Develop understanding of process to enable treatment of other austenitic alloys: Based on the results of the thermodynamic modeling and the wide range of compositions selected for evaluation, a model will be developed to predict the treatment of other austenitic alloys, including iron-based superalloys, nickel-based alloys, and cobalt-based alloys. The experimental heat results will be used to verify this model.

PROJECT PLANS AND PROGRESS

11. **Past Accomplishments:** Not applicable, project started in FY2004

12. **Future Plans:**

- Manufacture/procure alloys and specimens
- Process alloys

- Initial evaluations
- Microstructural characterization
- Thermodynamic modeling
- Corrosion testing: treated and untreated specimens
- Mechanical Testing
- Tribological evaluations
- Component testing
- Design and manufacture of experimental alloy

13. **Project Changes:** None.

14. **Commercialization Potential, Plans, and Activities:**
Swagelok owns the original intellectual property (IP) through several issued patents (US Patents 6,093,303, 6,165,597, and 6,461,448) and others pending, and will retain ownership. Swagelok intends to follow one of two paths with regard to commercialization and technology transfer:

- Swagelok may develop a strategic business unit with the purpose of offering the LTCSS process on a toll basis to interested end users; or
- Swagelok may, on a case-by-case basis, choose to enter into exclusive licensing arrangements for the technology.

The participants of this proposal, representing industry, academia and research, will identify industries and companies whose applications have the potential of benefiting from LTCSS. Such a team of participants provides the ideal partnering possibilities for the success of implementation of technology resulting from this program in the shortest time possible. The availability of super-hard wear- and corrosion-resistant austenitic stainless steels in other applications will strengthen the US domestic industry with enhanced products. Potential applications include fasteners; bearings; medical implants (stents, joint replacements); and consumer products, such as cutlery and razors.

15. **Patents, Publications, Presentations:** None to date.